



UNIVERSITI PUTRA MALAYSIA

**DETERMINANTS OF BONE MINERAL DENSITY IN
POSTMENOPAUSAL MALAY WOMEN**

RANI A/P SARMUGAM

FPSK (M) 2002 5

**DETERMINANTS OF BONE MINERAL DENSITY IN POSTMENOPAUSAL
MALAY WOMEN**

By

RANI A/P SARMUGAM

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Science**

November 2002



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fulfilment of the requirements for the degree of Master of Science

**DETERMINANTS OF BONE MINERAL DENSITY IN POSTMENOPAUSAL
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Chairperson: Associate Professor Zaitun Yassin, Ph.D.

Faculty: Medicine and Health Sciences

The objective of this study was to identify factors that determine the bone mineral density (BMD) in postmenopausal Malay women. A total of 113 subjects residing in the Klang Valley participated in the study on a voluntary basis. Study subjects were healthy Malay women aged between 50 to 65 years old who had attained menopause at least 5 years at the time of the study.

The BMD of total body, proximal femur, femoral neck, wards, trochanter and lumbar spine L2-L4 as well as fat mass (FM) and lean body mass (LBM) were measured using the dual energy X-ray absorptiometry (DEXA). Information on sociodemographic and reproductive history were collected using a questionnaire. Food intake was assessed using a three-day food record and a semiquantitative food frequency questionnaire. Physical activity was assessed using a three-day physical activity record, an open ended questionnaire and a pedometer. Knowledge, attitude and practice (KAP)

were assessed using a validated questionnaire. Body weight and height were measured using appropriate equipment and standard procedures. Dietary intake was analyzed using Nutritionist IV. Data were analyzed using SPSS Version 10.0. Stepwise regression analysis was used to determine the variables that were independently related to the BMD.

Stepwise regression analysis revealed that LBM, age, knowledge and protein intake explained 61.9% of the variance of proximal femur BMD. Meanwhile, LBM, knowledge, age, attitude towards osteoporosis and weight bearing exercise explained 64.3% of the variance of the femoral neck BMD. Age, LBM and knowledge explained 50.8% variance in the wards while 33.1% of the variance in the trochanter BMD was explained by LBM and age. As for the BMD of lumbar spine L2-L4, calcium intake and age were the most important variables ($R^2 = 0.440$) while FM and calcium intake were the most important variables ($R^2 = 0.359$) for total body BMD. In terms of reproductive history, only years since menopause was correlated with femoral neck BMD ($r = -0.199$, $p < 0.05$). However, it failed to show any significant effect when entered into the stepwise regression.

In conclusion, this study found that dietary intake especially calcium and protein intake, weight bearing activities, FM, LBM, age and knowledge as well as positive attitude towards osteoporosis contribute towards the BMD. However, it appears that these factors exchange places in importance at different sites of bone. Thus, although a portion of the variation in BMD is determined by unmodifiable factors such as age, there are some lifestyle

factors such as dietary intake and weight bearing physical activity, which help to modify the predisposition to osteoporosis.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**FAKTOR-FAKTOR PENENTU KETUMPATAN MINERAL TULANG DI
KALANGAN WANITA MELAYU MENOPAUS**

Oleh

RANI A/P SARMUGAM

November 2002

Pengerusi: Profesor Madya Zaitun Yassin, Ph.D.

Fakulti: Perubatan dan Sains Kesihatan

Objektif kajian ini adalah untuk mengenalpasti faktor penentu ketumpatan mineral tulang (KMT) di kalangan wanita Melayu posmenopaus. Seramai 113 subjek yang tinggal di sekitar Lembah Klang telah menyertai kajian ini secara sukarela. Subjek kajian merupakan wanita Melayu yang sihat berumur di antara 50 hingga 65 tahun dan telah menopaus sekurang-kurangnya lima tahun ketika kajian ini dijalankan.

KMT jumlah tubuh, pinggul, pangkal pinggul, wards dan trokanter dan lumbar L2L4 serta jisim lemak (JL) dan jisim otot tanpa lemak (JOTL) telah diukur dengan menggunakan 'dual energy X-ray absorptiometry' (DEXA). Maklumat sociodemografi dan sejarah reproduktif telah dikumpul dengan menggunakan borang soal selidik. Pengambilan makanan telah ditentukan dengan menggunakan borang rekod pengambilan makanan tiga hari dan borang kekerapan pengambilan makanan semikuantitatif. Aktiviti fizikal telah direkod dengan menggunakan borang rekod aktiviti fizikal tiga hari dan alat pedometer. Tahap pengetahuan, sikap dan amalan (KAP) telah ditentukan

dengan menggunakan borang soal selidik yang telah divalidasi. Pengambilan makanan dianalisis dengan menggunakan program Nutritionist IV. Data telah dianalisis dengan menggunakan SPSS Versi 10.0. Analisis regresi kaedah 'stepwise' telah digunakan untuk menentukan faktor yang mempengaruhi KMT secara bebas.

Hasil analisis regresi kaedah 'stepwise' menunjukkan bahawa JOTL, umur, skor pengetahuan dan pengambilan protein menjelaskan 61.9% variasi KMT pada tulang pinggul. Manakala JOTL, skor pengetahuan, umur, sikap terhadap osteoporosis dan aktiviti menanggung berat badan menjelaskan 64.3% variasi KMT di pangkal pinggul. Umur, JOTL dan tahap pengetahuan menerangkan 50.8% variasi di bahagian wards manakala 33.1% variasi KMT di bahagian trokanter dijelaskan oleh JOTL dan umur. Bagi bahagian lumbar L2L4, pengambilan kalsium dan umur merupakan angkubah yang sangat penting ($R^2 = 0.440$) manakala JL dan pengambilan kalsium merupakan angkubah yang sangat penting ($R^2 = 0.359$) bagi KMT jumlah badan. Bagi sejarah reproduktif, hanya jangkamasa selepas menopause berkaitan dengan KMT di bahagian pangkal pinggul ($r = -0.199$, $p < 0.05$). Walau bagaimanapun, ia gagal menunjukkan sebarang perkaitan yang signifikan selepas dimasukkan ke dalam analisis regresi kaedah 'stepwise'.

Kesimpulannya, kajian ini mendapati bahawa pengambilan diet terutamanya pengambilan kalsium dan protein, aktiviti menanggung berat badan, jisim lemak, JOTL, umur serta skor pengetahuan dan sikap terhadap osteoporosis menyumbang kepada KMT. Walaubagaimanapun, kepentingan faktor-faktor

ini berbeza mengikut bahagian tulang yang berlainan. Walaupun, sebahagian daripada variasi dalam KMT ini ditentukan oleh faktor-faktor yang tidak boleh diubahsuai seperti umur, faktor-faktor gaya hidup lain seperti pengambilan diet dan aktiviti fizikal yang boleh membantu mengubah kecenderungan terhadap osteoporosis.

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I certify that an Examination Committee met on 7th November 2002 to conduct the final examination of Rani a/p Sarmugam on her Master of Science thesis entitled "Determinants of Bone Mineral Density in Postmenopausal Malay Women" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Mohd. Nasir Mohd. Taib, Ph.D.

Department of Nutrition and Health Sciences,
Faculty of Medicine and Health Sciences,
Universiti Putra Malaysia.
(Chairman)

Zaitun Yassin, Ph.D.

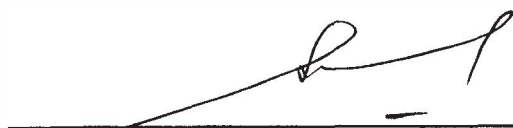
Associate Professor,
Department of Nutrition and Health Sciences,
Faculty of Medicine and Health Sciences,
Universiti Putra Malaysia.
(Member)

Suriah Abdul Rahman, Ph.D.

Associate Professor,
School of Chemical Science and Food Technology,
Faculty of Science and Technology,
Universiti Kebangsaan Malaysia.
(Member)

Mirmalini Kandiah, Ph.D.

Department of Nutrition and Health Sciences,
Faculty of Medicine and Health Sciences,
Universiti Putra Malaysia.
(Member)



SHAMSHER MOHAMAD RAMADILI, Ph.D.
Professor/Deputy Dean
School of Graduate School
Universiti Putra Malaysia

Date: 30 NOV 2002

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Zaitun Yassin, Ph.D.

Associate Professor,
Department of Nutrition and Health Sciences,
Faculty of Medicine and Health Sciences,
Universiti Putra Malaysia.
(Chairperson)

Suriah Abdul Rahman, Ph.D.

Associate Professor,
School of Chemical Science and Food Technology,
Faculty of Science and Technology,
Universiti Kebangsaan Malaysia.
(Member)

Mirnalini Kandiah, Ph.D.

Department of Nutrition and Health Sciences,
Faculty of Medicine and Health Sciences,
Universiti Putra Malaysia.
(Member)



AINI IDERIS, Ph.D.

Professor/Dean,
School of Graduate Studies,
Universiti Putra Malaysia.

Date: 9 JAN 2003

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

RANI A/P SARMUGAM

Date:

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LIST OF ABBREVIATIONS

| | |
|------|-------------------------------|
| BMD | Bone Mineral Density |
| BMC | Bone Mineral Content |
| BMAD | Bone Mineral Areal Density |
| DEXA | Dual Energy Absorptiometry |
| RDA | Recommended Dietary Allowance |
| BMI | Body Mass Index |
| WHR | Waist Hip Ratio |
| WHO | World Health Organization |
| OR | Odds Ratio |
| RR | Relative Risk |
| CI | Confidence Interval |

CHAPTER 1

INTRODUCTION

Bone is composed of hydroxyproline rich protein matrix crystals called hydroxipatite and a small amount of other substances such as collagen and some non-collagenous proteins such as osteonectin, osteocalcin and osteopontin. There are two types of bone tissues; cortical and trabecular. Each bone in the human body is composed of both types of these bone tissues. However, the relative proportion of these tissues differs according to the sites, for example the vertebrae consists of 50% trabecular bone and 50% of cortical bone and the femoral neck consists of 30% trabecular bone and 70% of cortical bone (Geusens, 1998). The cortical bone which predominates in the shafty long bones is the outer layer of the bone. It is compact, dense and has a slow bone turnover. Meanwhile the trabecular bone forms the internal support network for the cortical shell in the bone ends, vertebrae and other sites. It has a higher turnover rate compared to the cortical bone.

As living tissues, bone tissues are constantly removed and replaced throughout the life cycle. The cells that are responsible for the bone formation are called osteoblast while osteoclast cells cause bone resorption. An increase in osteoclastic activity or decreased osteoblastic activity will cause net bone loss.

After the peak bone mass has been attained, the amount of bone resorbed by osteoclasts is balanced by the amount of new bone formed by osteoblasts. However from menopause onwards, the bone resorption will increase at a rate higher than the bone formation (Genant et al., 1999) due to increased osteoclast activity or decreased osteoblast activity. A negative balance will occur when bone formation does not fully compensate for the amount of bone resorption, which in time will cause the trabecular bone especially, to become porous and its load carrying capacity to be reduced by 75% (Melton III et al., 1990). This causes the brittle bones to become fragile and increases the risk of fracture when a minimal force is applied.

The situation described above is called osteoporosis. It is defined by WHO (1994) as a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissues, leading to enhanced bone fragility and a consequent increase in fracture risk.

Riggs and Melton (1986) classified osteoporosis as Type I osteoporosis and Type II osteoporosis (Table 1.1). Type I or postmenopausal osteoporosis is mainly contributed by estrogen deficiency due to menopause. It leads to impaired intestinal and renal tubular calcium absorption that contributes to the negative calcium balance after menopause. Meanwhile, Type II or senile osteoporosis is mainly caused by the aging process. Two most important factors related to Type II osteoporosis are the decline of osteoblast function and impaired production of 25-hydroxyvitamin D which leads to decrease of calcium absorption and secondary hyperparathyroidism.

Table 1.1: Types of involutional osteoporosis

| | Type I | Type II |
|--|------------------------------|--------------------------|
| Age (year) | 51-75 | >70 |
| Sex ratio (F:M) | 6:1 | 2:1 |
| Type of bone loss | Mainly trabecular | Trabecular and cortical |
| Rate of bone loss | Accelerated | Not accelerated |
| Fracture sites | Vertebrae and distal radius | Vertebrae and hip |
| Parathyroid function | Decreased | Increased |
| Calcium absorption | Decreased | Decreased |
| Metabolism of 25-OH-D to 1,25(OH) ₂ D | Secondary decrease | Primary decrease |
| Main causes | Factors related to menopause | Factors related to aging |

Source: Riggs and Melton III, 1986

Senile osteoporosis (Type II) begins at age 40. From then on, the bone mass will decrease at approximately 0.6 to 0.7% yearly and continues throughout life. On the other hand, postmenopausal osteoporosis (Type I) starts once a woman reaches menopause until 15 to 20 years later with about 1% up to 5% loss of trabecular bone yearly (Hurley and Khosla, 1997).

Table 1.2 shows the risk factors of osteoporosis (Suzuki, 1998). The individual factors are also known as unmodifiable risk factors such as genetic, race and sex, which cannot be altered. The modifiable factors are the nutritional and lifestyle factors such as calcium intake and regular exercise, which can be altered in order to prevent osteoporosis.

Table 1.2: Risk factors for osteoporosis

Individual factors

Race
Heredity /Genetic
Sex (female higher risk than male)
Age (postmenopausal women in particular)
Body build (slender, small and thin person)

Nutritional factors

Calcium deficiency
Alcohol and smoking
Excessive intake of salt and phosphorus
Weight loss due to extreme weight control (inappropriate diet)

Physical factors

Insufficient exercise (long term bed ridden)
Muscle paralysis (by stroke etc.)
Decrease in exercise capacity
Zero gravity (astronauts)

Disease or drug related factors

Premenopausal ovariectomy or hypogonadism
Gastrectomy
Anorexia nervosa
Steroid use
Source: Suzuki,1998

Statement of the Problem

Osteoporosis has become one of the major public health issues. It has drawn a lot of attention from health care professionals as well as the public due to increase in life expectancy, number of elderly and the cost associated with fractures.

The recent National Institute of Health (NIH) Consensus Statement (2000) reported that the direct financial expenditure for treatment due to osteoporotic fractures is estimated to be around US \$10 to US \$15 billion annually. Besides, there is also indirect financial loss due to lost of wages or productivity of the patient or caretaker due to osteoporosis.

Apart from the Medicare cost, osteoporotic fractures also lead to significant bone pain, disability and disfigurement causing a decrease in the quality of life (Barret-Connor, 1995). It also has a significant effect on the physical and psychosocial aspect of the patients and their families. Death related to respiratory disease from bed rest and hospitalization due to hip fractures is about 12% to 20% (NIH Consensus Statement, 2000).

In the United States of America (USA), 10 million individuals already have osteoporosis and 18 million more have low bone mass, placing them at high risk of getting osteoporosis (NIH Consensus Statement, 2000). The Asian Osteoporosis Study reported that the age adjusted rate of osteoporosis for men and women per 100,000 were 180 and 459 for Hong Kong, 164 and 442 for Singapore, 88 and 218 for Malaysia, 114 and 289 for Thailand (Table 1.3). The rates for both sex doubled from 65 to 75 years old and increased exponentially from the age of 75 onwards. Even though the rates in this region is slightly lower than the rate in the USA, it is expected that it will continue to rise along with the increase in life expectancy, rapid economic development and urbanization (Lau et al., 2001).

In Malaysia, there are about 1.2 million elderly, which is about 6.8% of the total population (Department of Statistics, 1999). This percentage is projected to increase to 8.3% by 2010 and 11.3% by 2020 (Ministry of Health, 1999).

Table 1.3: Hip fracture discharge (number and rates per 100,000) by age, sex and country (region) in 1997– 1998)

| | Hong Kong | | Singapore | | Malaysia | | Thailand | | US white | |
|--------------------------|-----------|------|-----------|------|----------|------|----------|------|----------|------|
| Age groups (years) | No. | Rate | No. | Rate | No. | Rate | No. | Rate | No. | Rate |
| Men | | | | | | | | | | |
| 50-54 | 26.0 | 15.8 | 19.0 | 22.0 | 50 | 13.8 | 6 | 27.1 | 41 | 33 |
| 55-59 | 43 | 30.8 | 23 | 34.5 | 58 | 20.1 | 9 | 35.8 | | |
| 60-64 | 74 | 53.0 | 25 | 48.6 | 83 | 37.6 | 9 | 35.2 | 44 | 81 |
| 65-69 | 108 | 89.5 | 38 | 98.6 | 90 | 58.3 | 17 | 77.2 | 67 | 123 |
| 70-74 | 164 | 189 | 128 | 210 | 95 | 96.5 | 21 | 144 | 64 | 119 |
| 75-79 | 222 | 404 | 212 | 611 | 331 | 320 | 19 | 227 | 87 | 338 |
| 80-84 | 272 | 932 | | | | | 17 | 421 | 129 | 851 |
| 85+ | 236 | 1639 | | | | | 27 | 727 | 181 | 1894 |
| Age adjusted to US white | | 180 | | 164 | | 88 | | 114 | | 187 |
| Women | | | | | | | | | | |
| 50-54 | 18 | 13.4 | 15 | 14.1 | 32 | 9.2 | 2 | 9.5 | 66 | 60 |
| 55-59 | 41 | 35.2 | 26 | 34.0 | 76 | 26.5 | 15 | 59.1 | | |
| 60-64 | 81 | 64.4 | 54 | 81.1 | 112 | 48.2 | 24 | 88.9 | 93 | 117 |
| 65-69 | 209 | 174 | 99 | 195 | 179 | 103 | 35 | 148 | 149 | 252 |
| 70-74 | 354 | 359 | 135 | 408 | 274 | 230 | 56 | 361 | 258 | 437 |
| 75-79 | 573 | 820 | 1051 | 1369 | 892 | 644 | 61 | 657 | 394 | 850 |
| 80-84 | 635 | 1405 | | | | | 43 | 898 | 509 | 1679 |
| 85+ | 1003 | 3012 | | | | | 30 | 605 | 799 | 3099 |
| Age adjusted to US white | | 459 | | 442 | | 218 | | 269 | | 535 |

Source: Lau et al., 2001